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Title: Radioactive Target Holder for DANCE

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Radioactive Target Holder for DANCE

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August 22, 2003

1 Introduction

Neptunium-237 is a major constituent of spent nuclear fuel. Estimates place the amount of Np-237 bound for the Yucca Mountain high-level waste repository at 40 metric tons. The Department of Energy's Advanced Fuel Cycle Initiative program is evaluating methods for transmuting the actinide waste that will be generated by future operation of commercial nuclear power plants, thereby reducing or possibly eliminating the need for a second repository beyond Yucca Mountain. The critical parameter that defines the transmutation efficiency of actinide isotopes is the neutron fission-to-capture ratio for the particular isotope in a given neutron spectrum. The calculation of transmutation efficiency therefore requires accurate fission and capture cross sections over the range of neutron energies in both the reactor in which the actinides are produced (typically thermal systems) and the transmuter (most likely a fast spectrum system). Current Np-237 evaluations available for transmuter system studies show significant discrepancies in both the fission and capture cross sections in the energy regions of interest. Therefore, a proposal to measure the Np-237 capture cross section using DANCE was made.
Since DANCE had not run a trans-uranic target yet it was essential to design and construct a radioactive target holder for the job. The current target holder consists of a ladder that can hold up to 3 targets and is driven by a stepper motor into and out of the beam line. Since the targets are mounted freely and are not inside a container this method is not sufficient for carrying targets with alpha emitters with alpha energies higher than 5 MeV. These Actinides can "move" away from the target plating by alpha recoil. Therefor it was essential to design and test a new target holder for the DANCE detector.

2 Target Holder Design

To use the new design of the radioactive target holder (RTH) a new beam pipe had to be constructed. Figure 1, 2, 3 and 4 show the technical drawings of the design. The new beam pipe is a straight pipe and does not have a cross. This allows an aluminum cylinder (the RTH) to slide into it. The new RTH consists of an aluminum sleeve with kapton windows on both ends. The windows are supported by an aluminum frame (see Figure 11) that can be screwed into and out of the aluminum sleeve. Inside the RTH sleeve an aluminum lip has been machined to hold the aluminum target foil support ring (TFSR) (see detail 3 in Figure 12. The beam pipe for the RTH is designed with an index so that if the RTH is inserted into pipe its alignment is reproducible.

Hardware to mount the TFSR with the radioactive target glued to was also designed. Detail 4 in Figure 12 shows an aluminum pedestal on which the TFSR can be placed and the RTH sleeve can then be slid over the outer diameter of the pedestal until the TFSR touches the lip in the RTH sleeve. The the sleeve is turned over with the pedestal still in it.The pedestal is then removed. Should it be stuck inside the sleeve the aluminum insert (detail 5 in Figure 13 can be used th extract the pedestal. After that the TFSR is glued to the RTH sleeve.

To ensure that the RTH stays in position on the index and does not slide in the opposite direction a restraint in shape of a thin aluminum rod (see Figure 10 has been design. It will be placed into the KF beam pipe and lay against a safety KF-O-ring holder (Figure 9).

To further reduce the possibility of moving the RTH, the vacuum system has been redesigned so that the beam pipe is pumped on in direction of the RTH to the index and let up to air from the opposite site. This way the differential pressure ensures in both cases that the RTH is pressed against the index. Figures 5, 6, 7, 8, 14, 15, and 16 show the design of the beam pipe components.

3 Vacuum test

Twelve RTHs were built. Eleven of them were tested under vacuum to see if the kapton windows held up during the pump-out and vent phase. The experiment was conducted by placing each holder into the designed beam

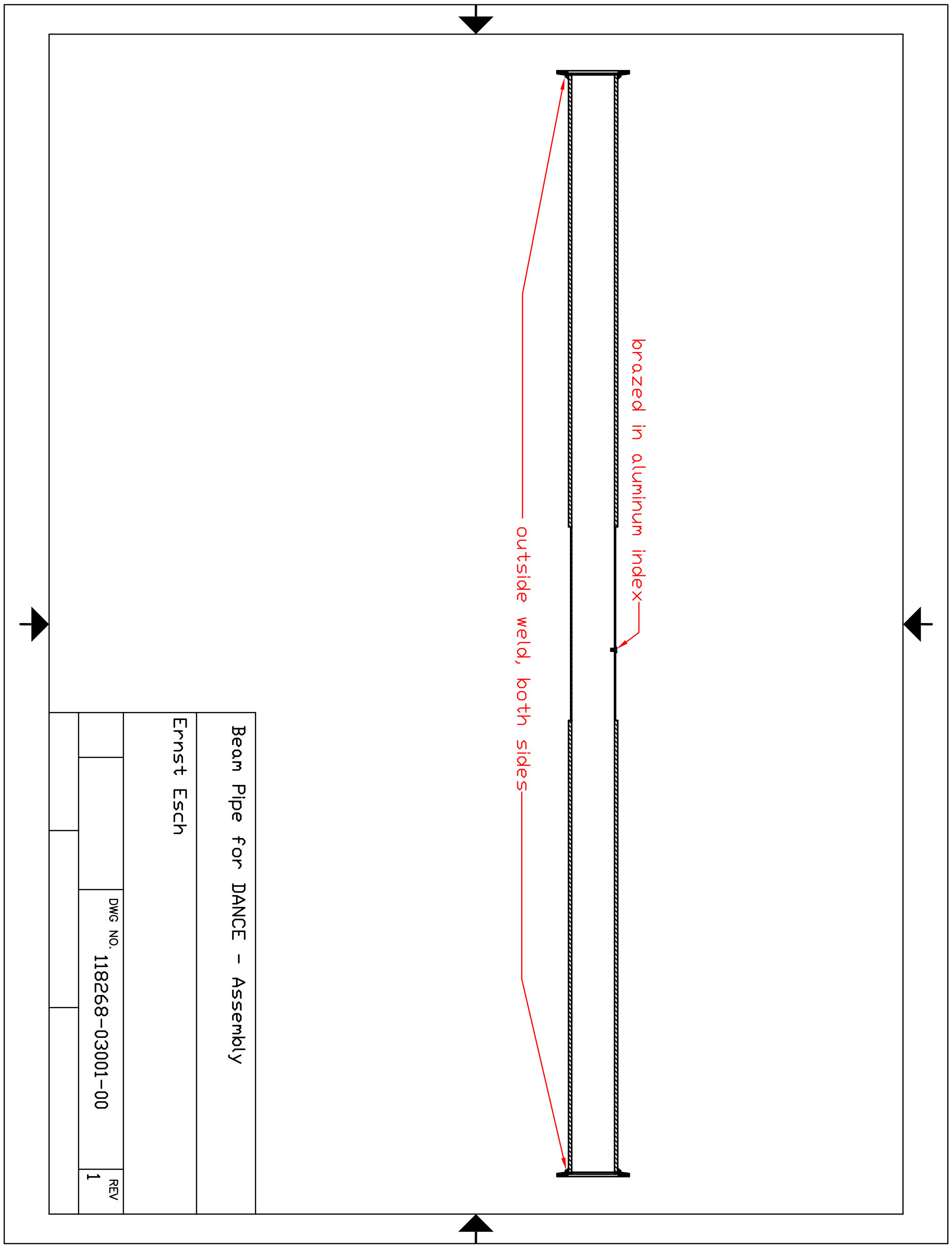

brazed in aluminum index
outside weld, both sides
Beam Pipe for DANCE - Assembly
Ernst Esch
DWG NO.
118268-03001-00
REV
1

Figure 1:

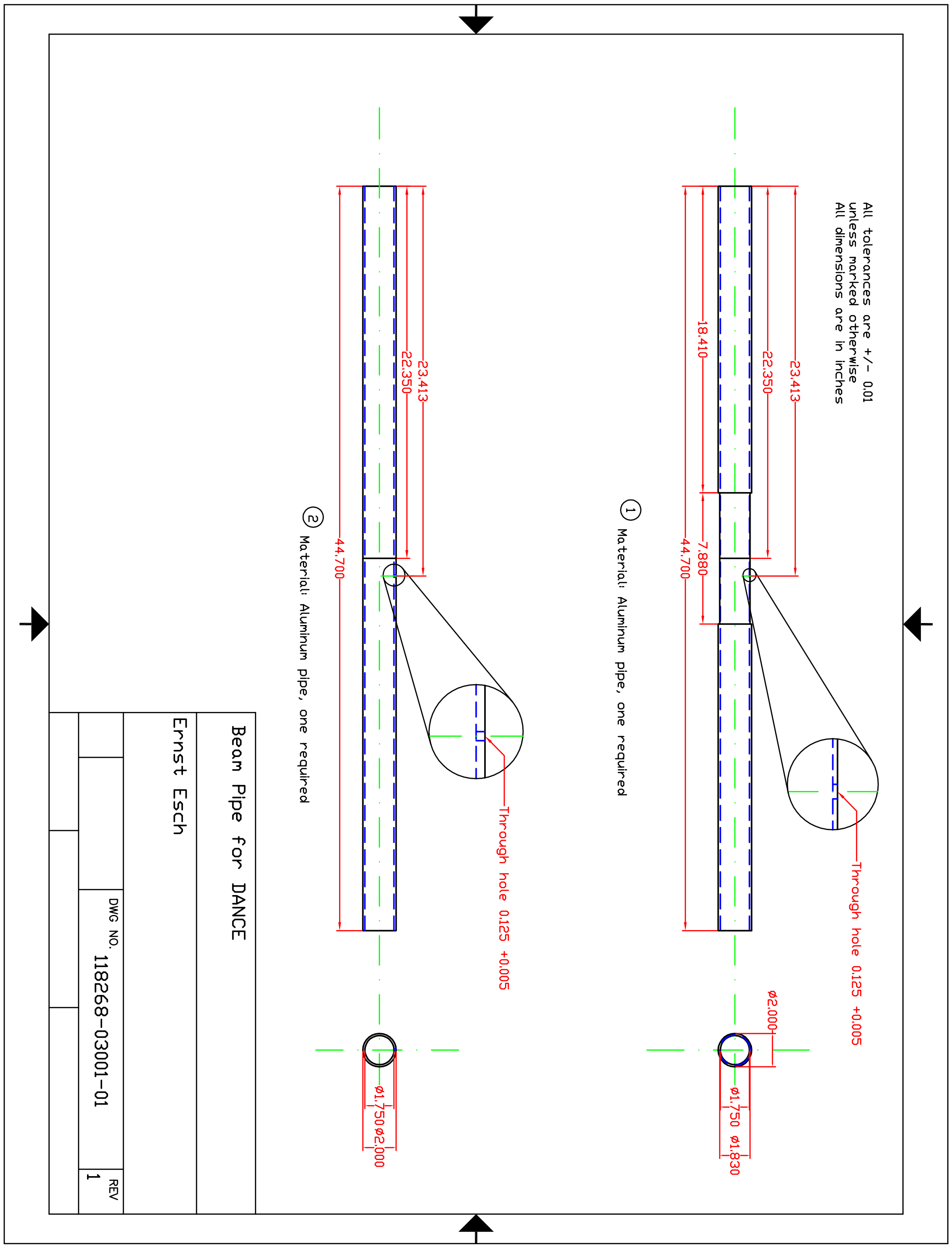
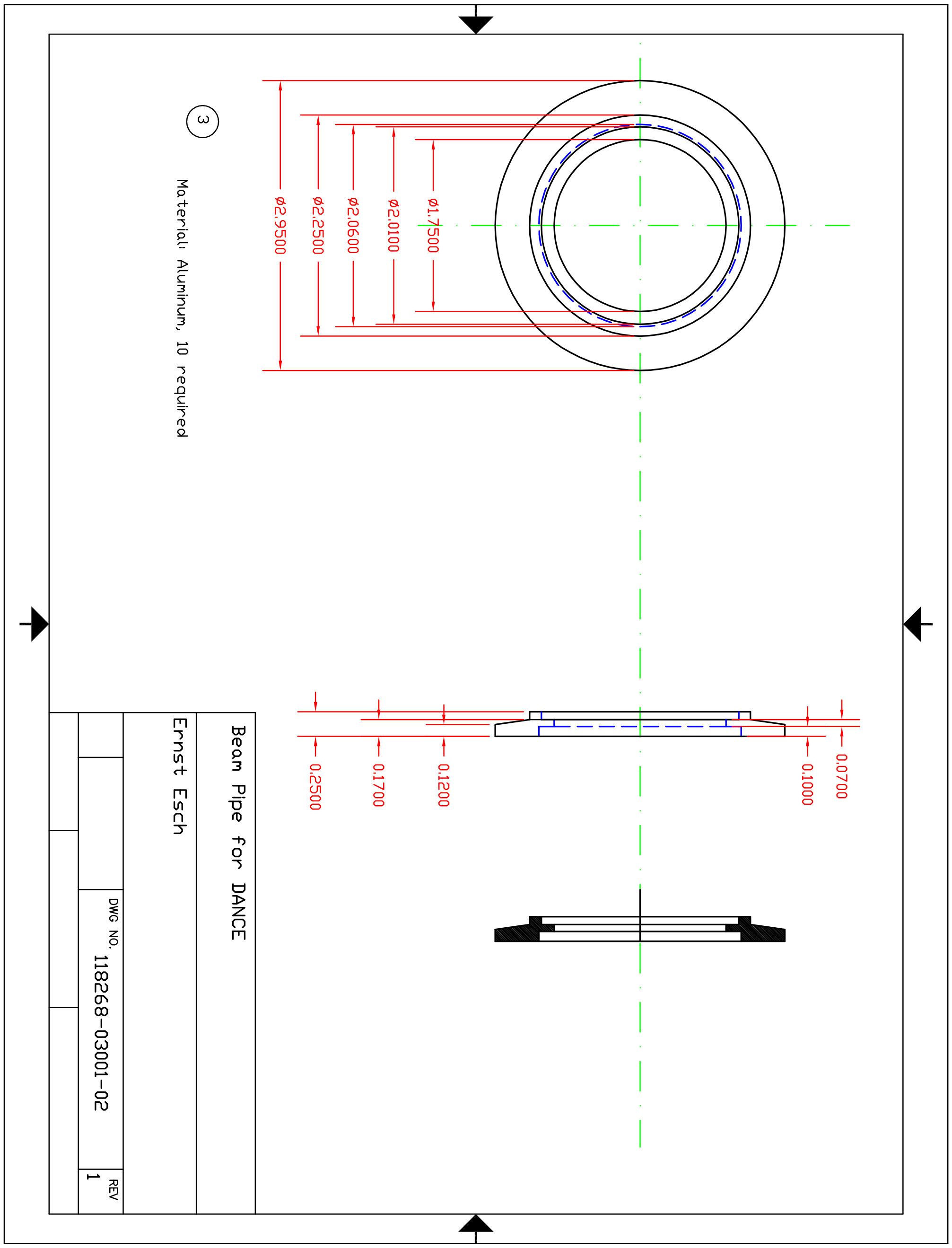
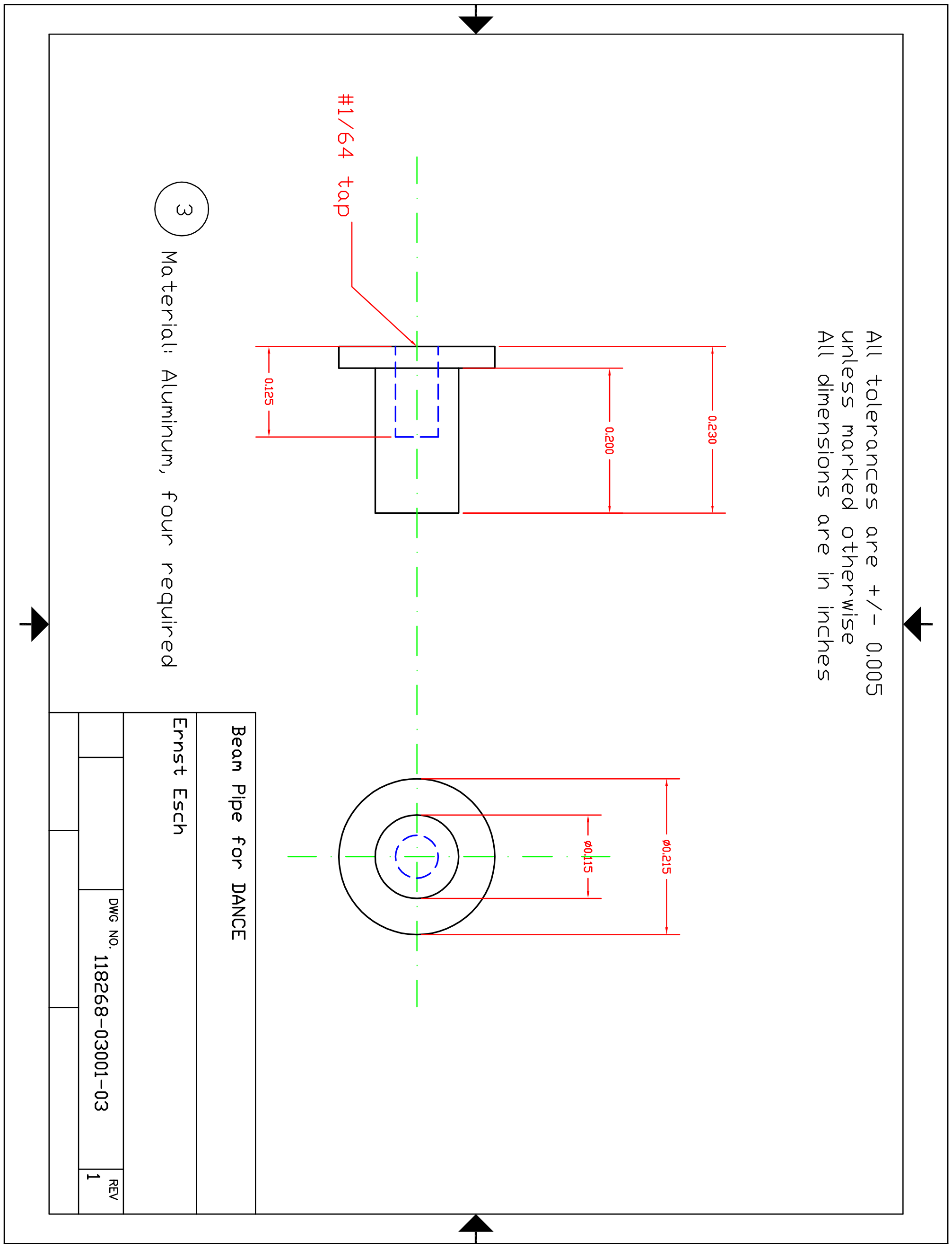

All tolerances are +/- 0.01
unless marked otherwise
All dimensions are in inches
1
Material: Aluminum pipe, one required
2
Material: Aluminum pipe, one required
23.413
22.350
18.410
7.880
44.700
Through hole 0.125 +0.005
ø2.000
ø1.750
ø1.830
Beam Pipe for DANCE
Ernst Esch
DWG NO.
118268-03001-01
REV
1

Figure 2:



3
Material: Aluminum, 10 required
ø2.9500
ø2.2500
ø2.0600
ø2.0100
ø1.7500
0.2500
0.1700
0.1200
0.1000
0.0700
Beam Pipe for DANCE
Ernst Esch
DWG NO.
118268-03001-02
REV
1

Figure 3:



All tolerances are +/- 0.005
unless marked otherwise
All dimensions are in inches
#1/64 tap
0.125
0.200
0.230
ø0.115
ø0.215
3
Material: Aluminum, four required
Beam Pipe for DANCE
Ernst Esch
DWG NO.
118268-03001-03
REV
1

Figure 4:

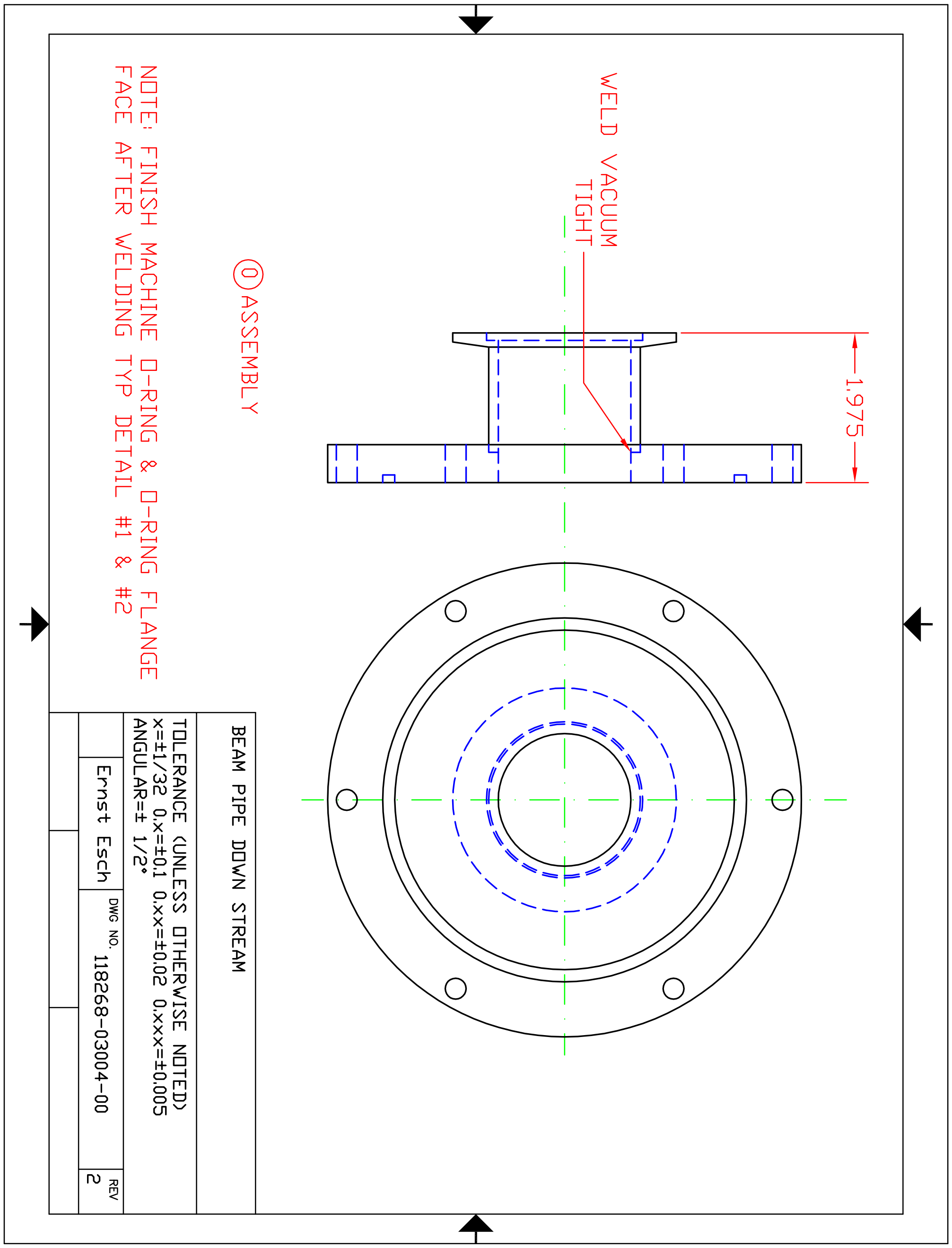

WELD VACUUM
TIGHT
1.975
0 ASSEMBLY
NOTE: FINISH MACHINE O-RING & O-RING FLANGE
FACE AFTER WELDING TYP DETAIL #1 & #2
BEAM PIPE DOWN STREAM
TOLERANCE (UNLESS OTHERWISE NOTED)
x=±1/32 0.x=±0.1 0.xx=±0.02 0.xxx=±0.005
ANGULAR=± 1/2°
Ernst Esch
DWG NO.
118268-03004-00
REV
2

Figure 5:

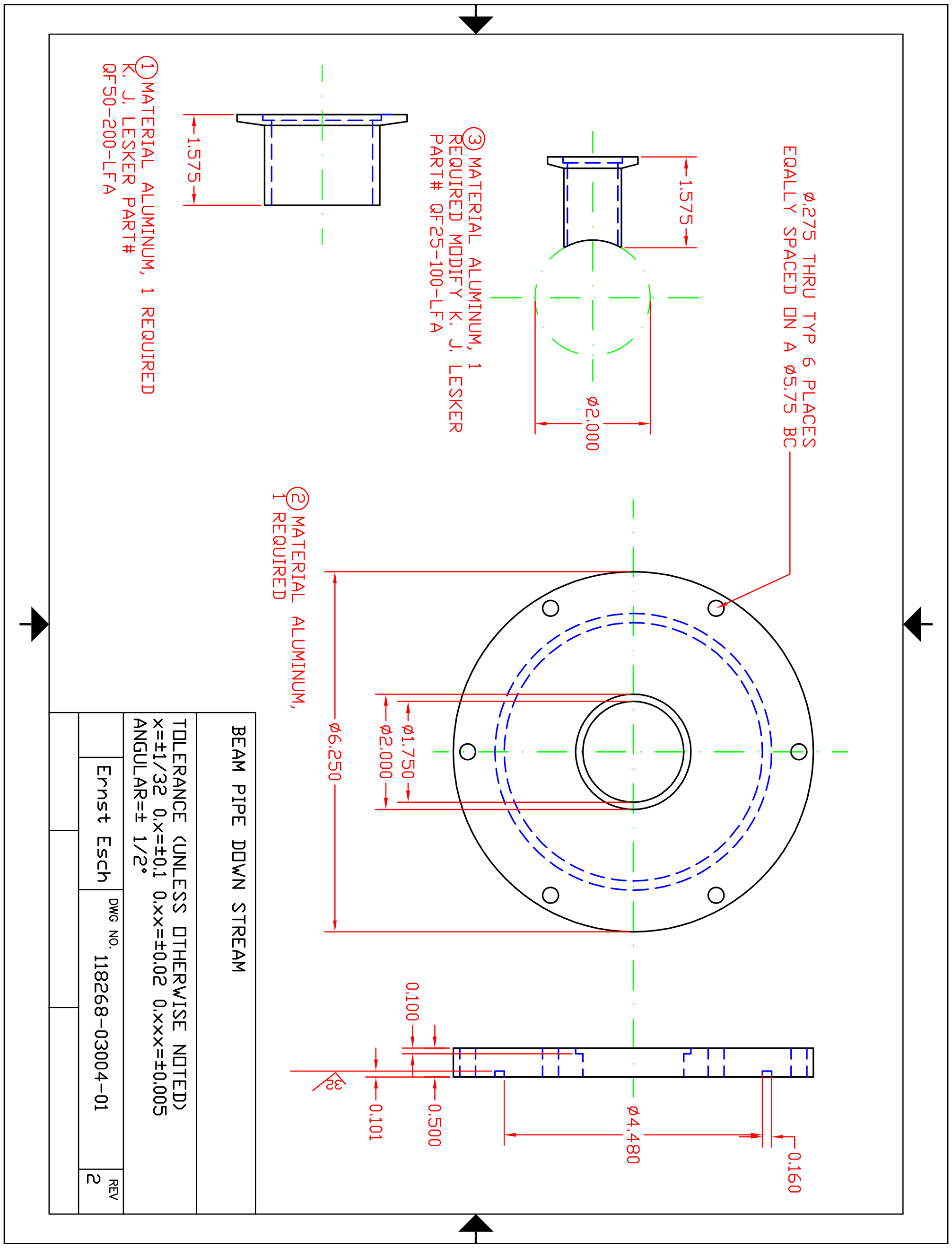

ø.275 THRU TYP 6 PLACES
EQALLY SPACED ON A ø5.75 BC
1.575
ø2.000
3 MATERIAL ALUMINUM, 1
REQUIRED MODIFY K. J. LESKER
PART# QF25-100-LFA
1.575
1 MATERIAL ALUMINUM, 1 REQUIRED
K. J. LESKER PART#
QF50-200-LFA
2 MATERIAL ALUMINUM,
1 REQUIRED
ø6.250
ø2.000
ø1.750
0.100
0.500
0.101
ø4.480
0.160
BEAM PIPE DOWN STREAM
TOLERANCE (UNLESS OTHERWISE NOTED)
x=±1/32 0.x=±0.1 0.xx=±0.02 0.xxx=±0.005
ANGULAR=± 1/2°
Ernst Esch
DWG NO.
118268-03004-01
REV
2

Figure 6:

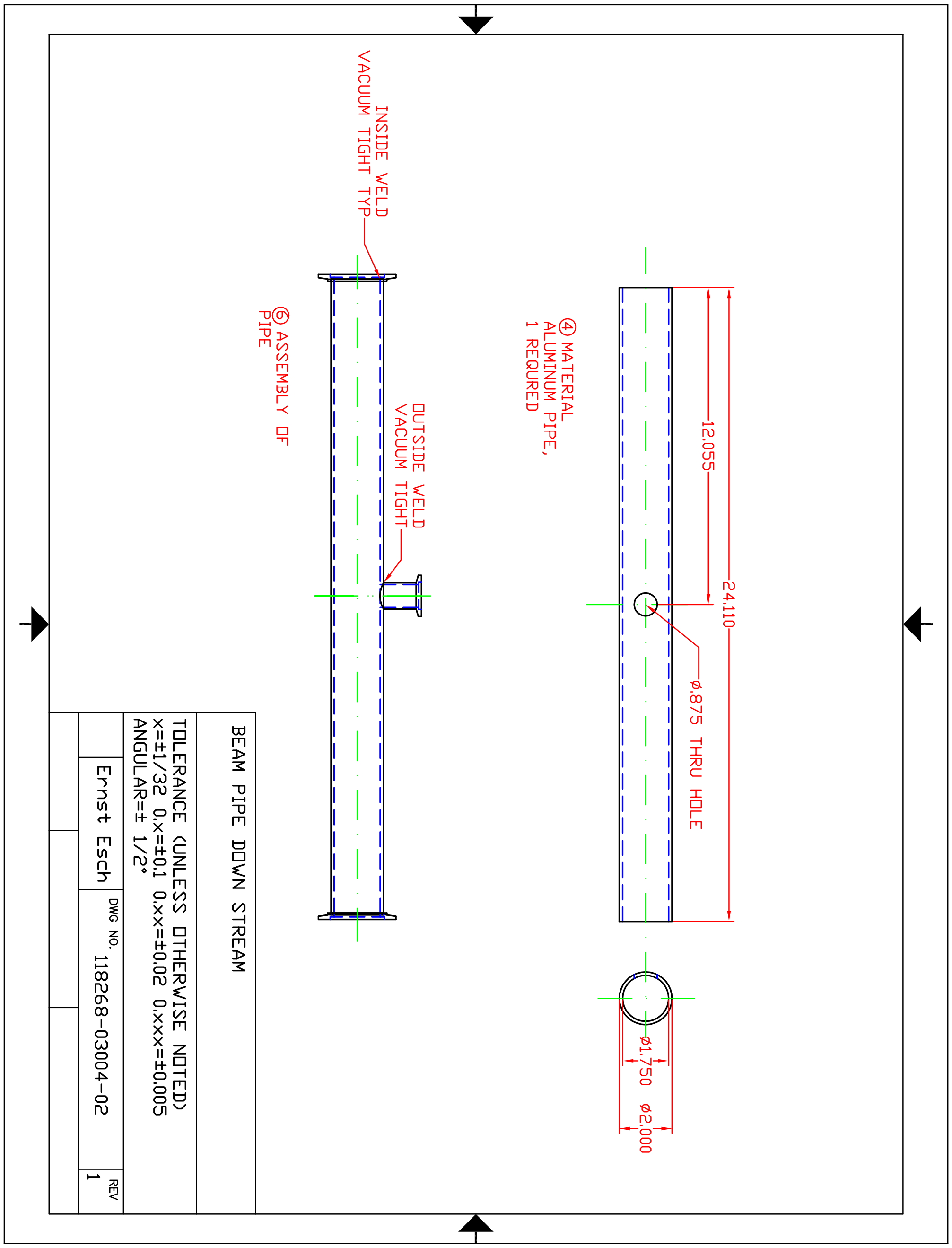

INSIDE WELD
VACUUM TIGHT TYP
6 ASSEMBLY OF
PIPE
OUTSIDE WELD
VACUUM TIGHT
4 MATERIAL
ALUMINUM PIPE,
1 REQUIRED
12.055
24.110
ø.875 THRU HOLE
ø1.750
ø2.000
BEAM PIPE DOWN STREAM
TOLERANCE (UNLESS OTHERWISE NOTED)
x=±1/32 0.x=±0.1 0.xx=±0.02 0.xxx=±0.005
ANGULAR=± 1/2°
Ernst Esch
DWG NO.
118268-03004-02
REV
1

Figure 7:

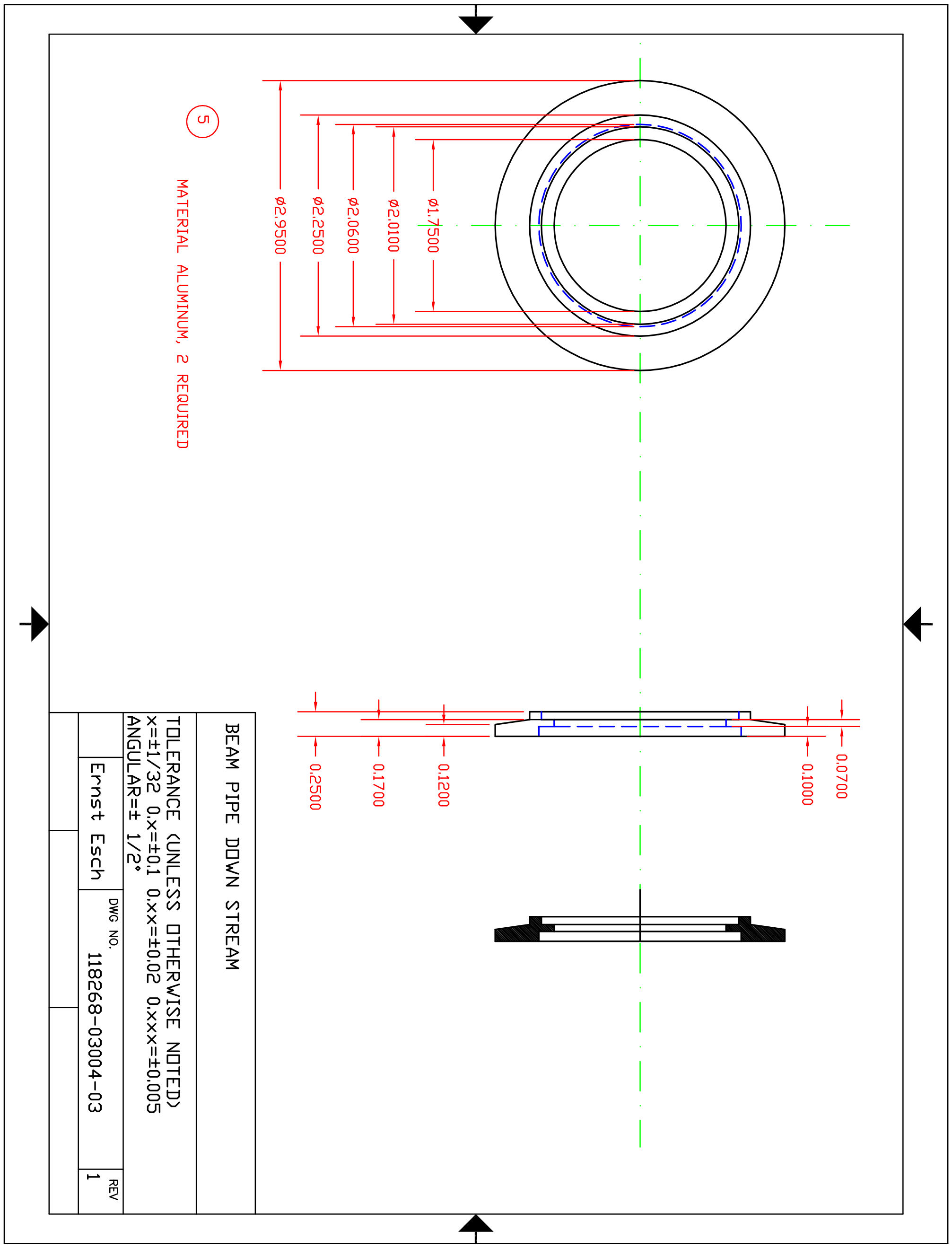

5
MATERIAL ALUMINUM, 2 REQUIRED
Ø2.9500
Ø2.2500
Ø2.0600
Ø2.0100
Ø1.7500
0.2500
0.1700
0.1200
0.1000
0.0700
BEAM PIPE DOWN STREAM
TOLERANCE (UNLESS OTHERWISE NOTED)
x=±1/32 0.x=±0.1 0.xx=±0.02 0.xxx=±0.005
ANGULAR=± 1/2°
Ernst Esch
DWG NO.
118268-03004-03
REV
1

Figure 8:

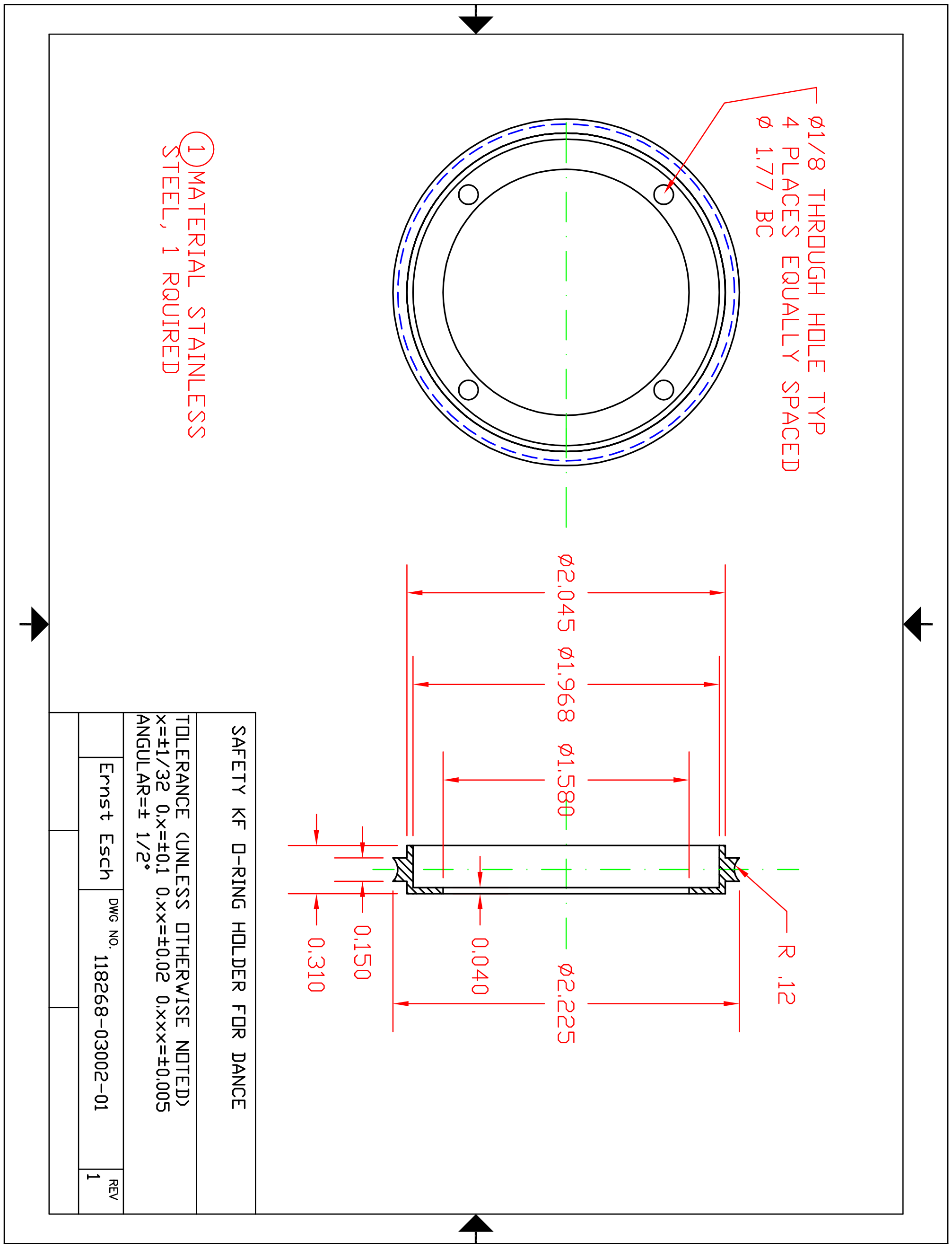

Ø1/8 THROUGH HOLE TYP
4 PLACES EQUALLY SPACED
Ø 1.77 BC
1 MATERIAL STAINLESS
STEEL, 1 RQUIRED
Ø2.045
Ø1.968
Ø1.580
R .12
Ø2.225
0.040
0.150
0.310
SAFETY KF O-RING HOLDER FOR DANCE
TOLERANCE (UNLESS OTHERWISE NOTED)
x=±1/32 0.x=±0.1 0.xx=±0.02 0.xxx=±0.005
ANGULAR=± 1/2°
Ernst Esch
DWG NO.
118268-03002-01
REV
1

Figure 9:

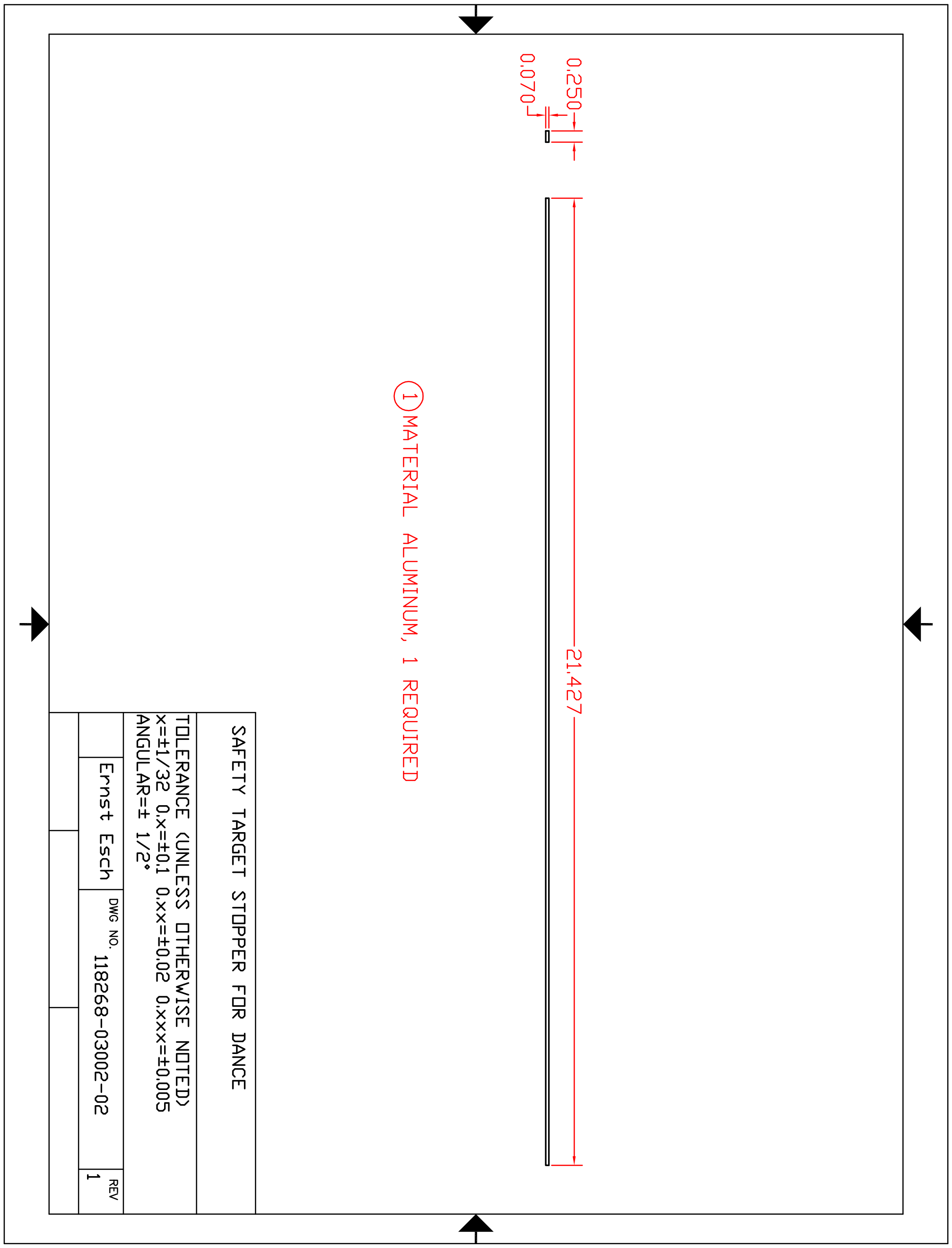

0.250
0.070
21.427
1 MATERIAL ALUMINUM, 1 REQUIRED
SAFETY TARGET STOPPER FOR DANCE
TOLERANCE (UNLESS OTHERWISE NOTED)
x=±1/32 0.x=±0.1 0.xx=±0.02 0.xxx=±0.005
ANGULAR=± 1/2°
Ernst Esch
DWG NO.
118268-03002-02
REV
1

Figure 10:

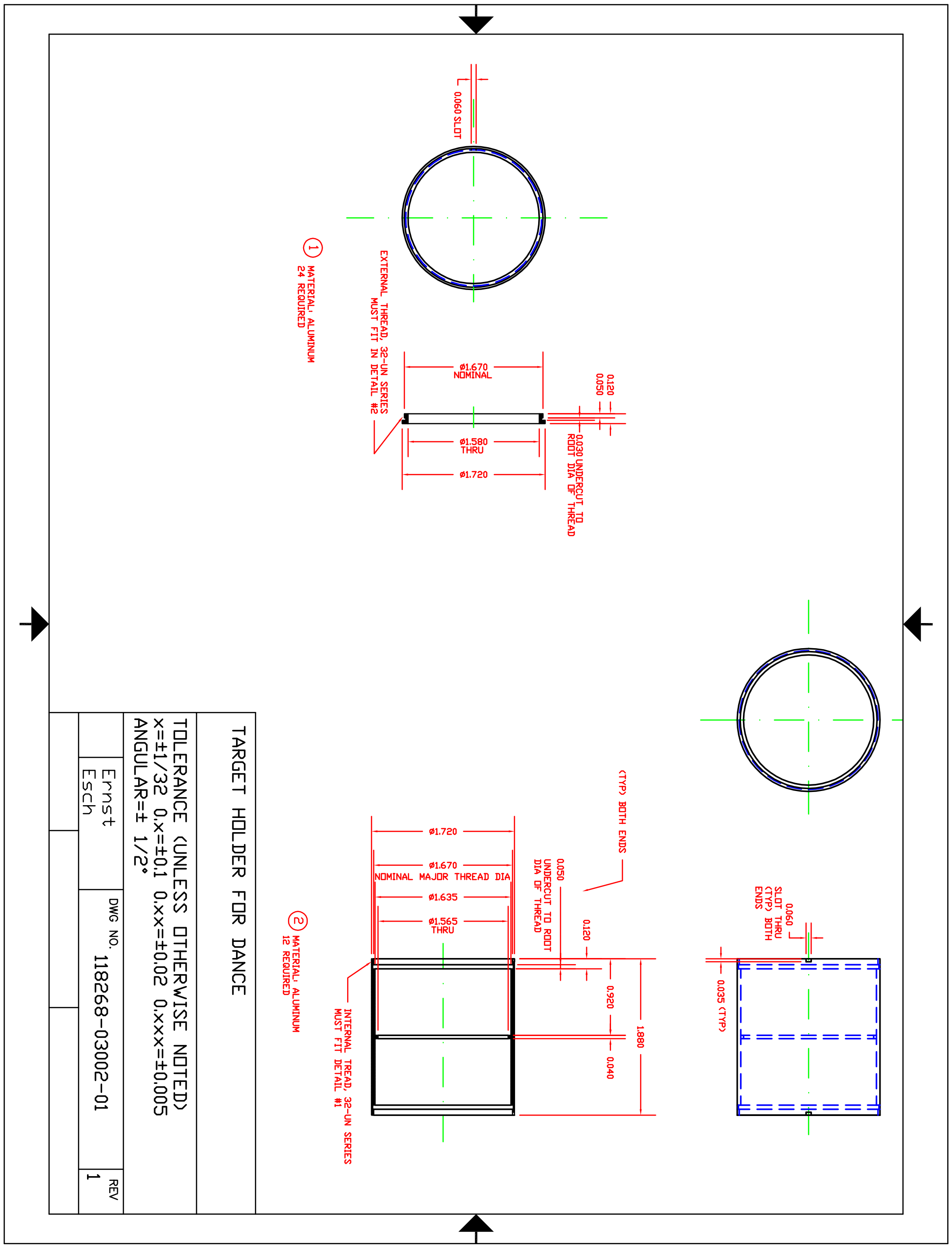

TARGET HOLDER FOR DANCE
TOLERANCE (UNLESS OTHERWISE NOTED)
x=±1/32 0.x=±0.1 0.xx=±0.02 0.xxx=±0.005
ANGULAR=± 1/2°
Ernst Esch
DWG NO.
118268-03002-01
REV
1
0.060 SLOT
MATERIAL: ALUMINUM
24 REQUIRED
EXTERNAL THREAD, 32-UN SERIES
MUST FIT IN DETAIL #2
ø1.670
NOMINAL
ø1.580
THRU
ø1.720
0.120
0.050
0.030 UNDERCUT TO
ROOT DIA OF THREAD
(TYP) BOTH ENDS
ø1.720
ø1.670
NOMINAL MAJOR THREAD DIA
ø1.635
ø1.565
THRU
0.050
UNDERCUT TO ROOT
DIA OF THREAD
0.120
0.920
0.040
1.880
MATERIAL: ALUMINUM
12 REQUIRED
INTERNAL TREAD, 32-UN SERIES
MUST FIT DETAIL #1
0.060
SLOT THRU
(TYP) BOTH
ENDS
0.035 (TYP)

Figure 11:

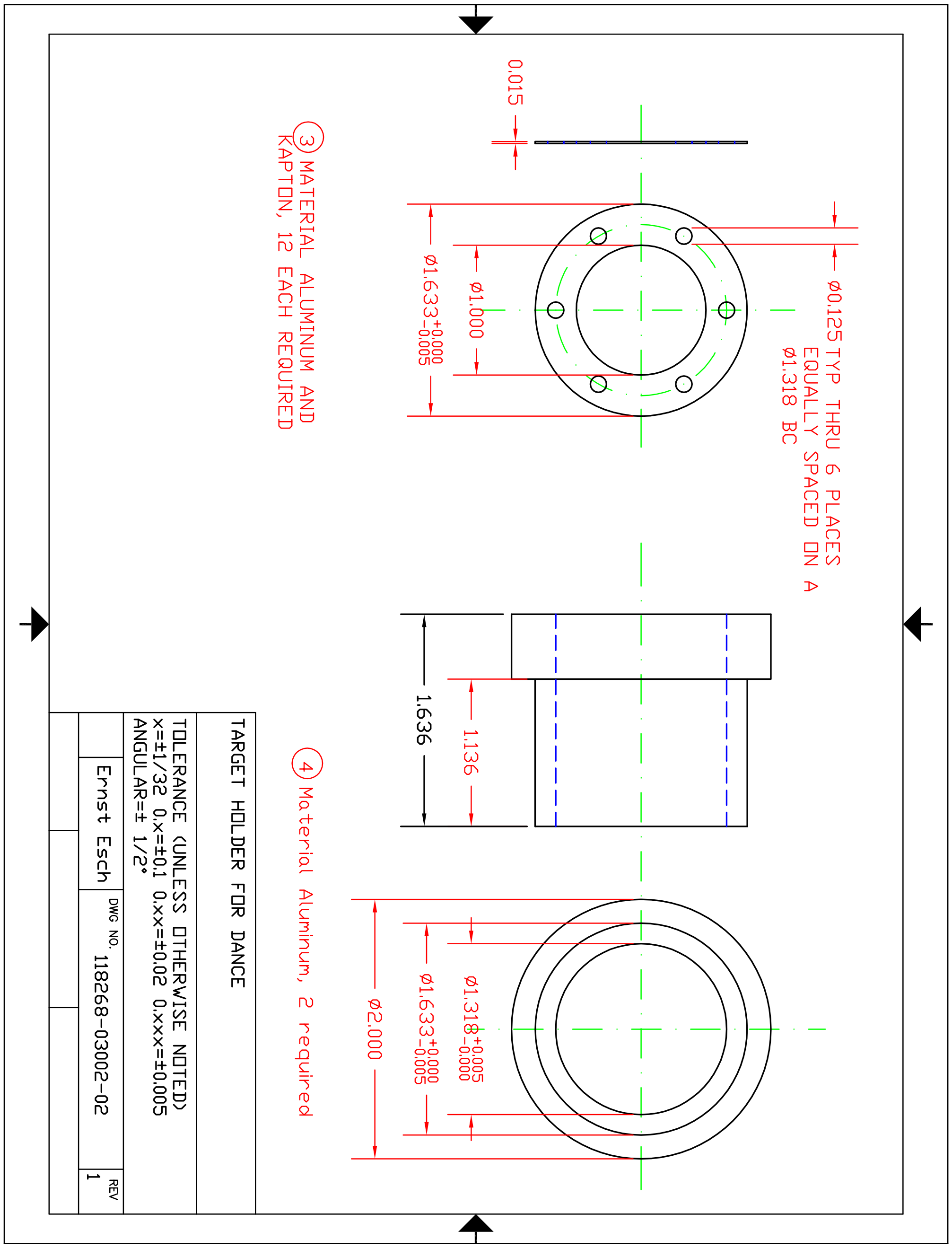
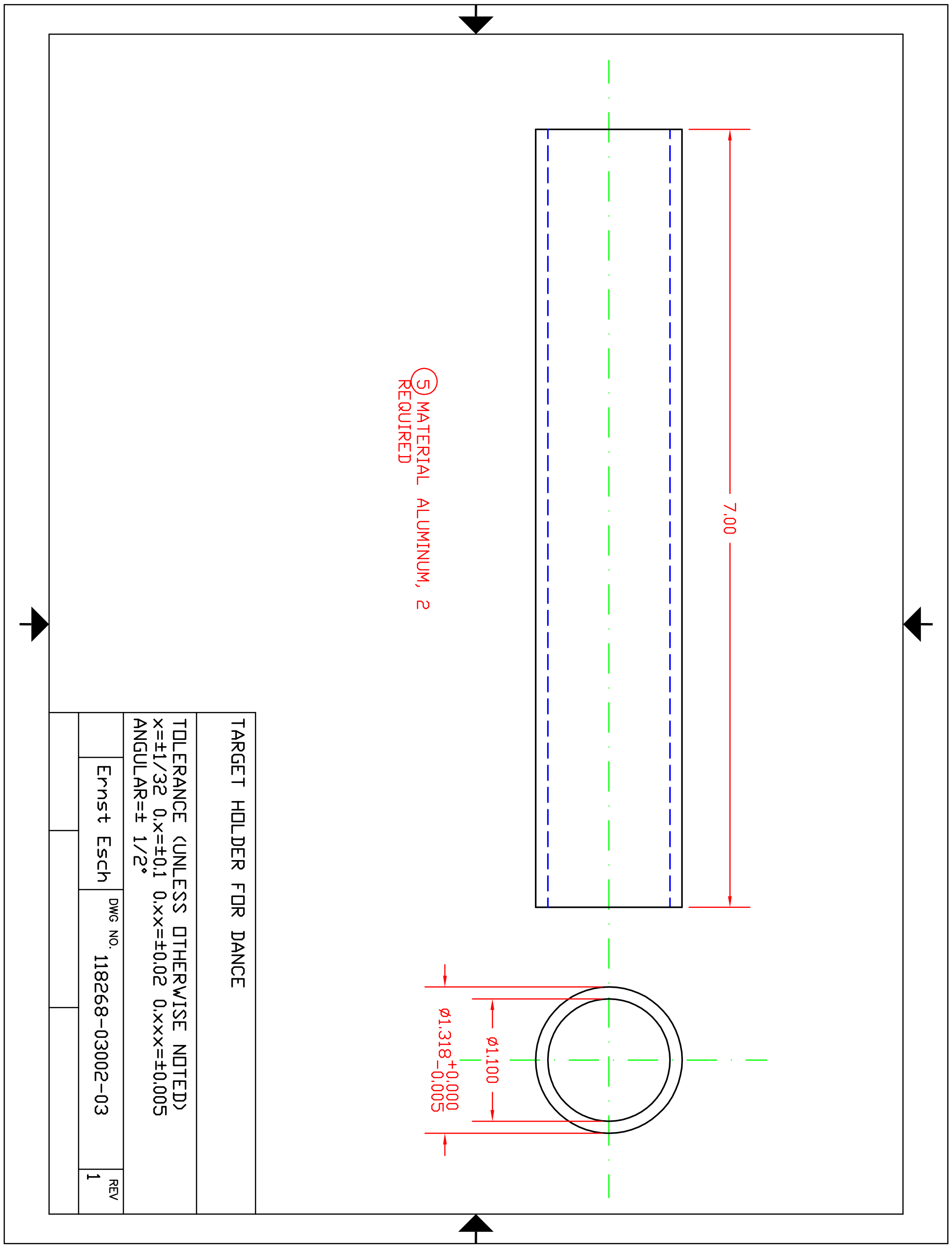

0.015
Ø0.125 TYP THRU 6 PLACES
EQUALLY SPACED ON A
Ø1.318 BC
Ø1.000
Ø1.633 +0.000 -0.005
3 MATERIAL ALUMINUM AND
KAPTON, 12 EACH REQUIRED
1.636
1.136
4 Material Aluminum, 2 required
Ø2.000
Ø1.633 +0.000 -0.005
Ø1.318 +0.005 -0.000
TARGET HOLDER FOR DANCE
TOLERANCE (UNLESS OTHERWISE NOTED)
x=±1/32 0.x=±0.1 0.xx=±0.02 0.xxx=±0.005
ANGULAR=± 1/2°
Ernst Esch
DWG NO.
118268-03002-02
REV
1

Figure 12:



TARGET HOLDER FOR DANCE
TOLERANCE (UNLESS OTHERWISE NOTED)
x=±1/32 0.x=±0.1 0.xx=±0.02 0.xxx=±0.005
ANGULAR=± 1/2°
Ernst Esch
DWG NO.
118268-03002-03
REV
1
5 MATERIAL ALUMINUM, 2 REQUIRED
7.00
Ø1.100
Ø1.318 +0.000 -0.005

Figure 13:

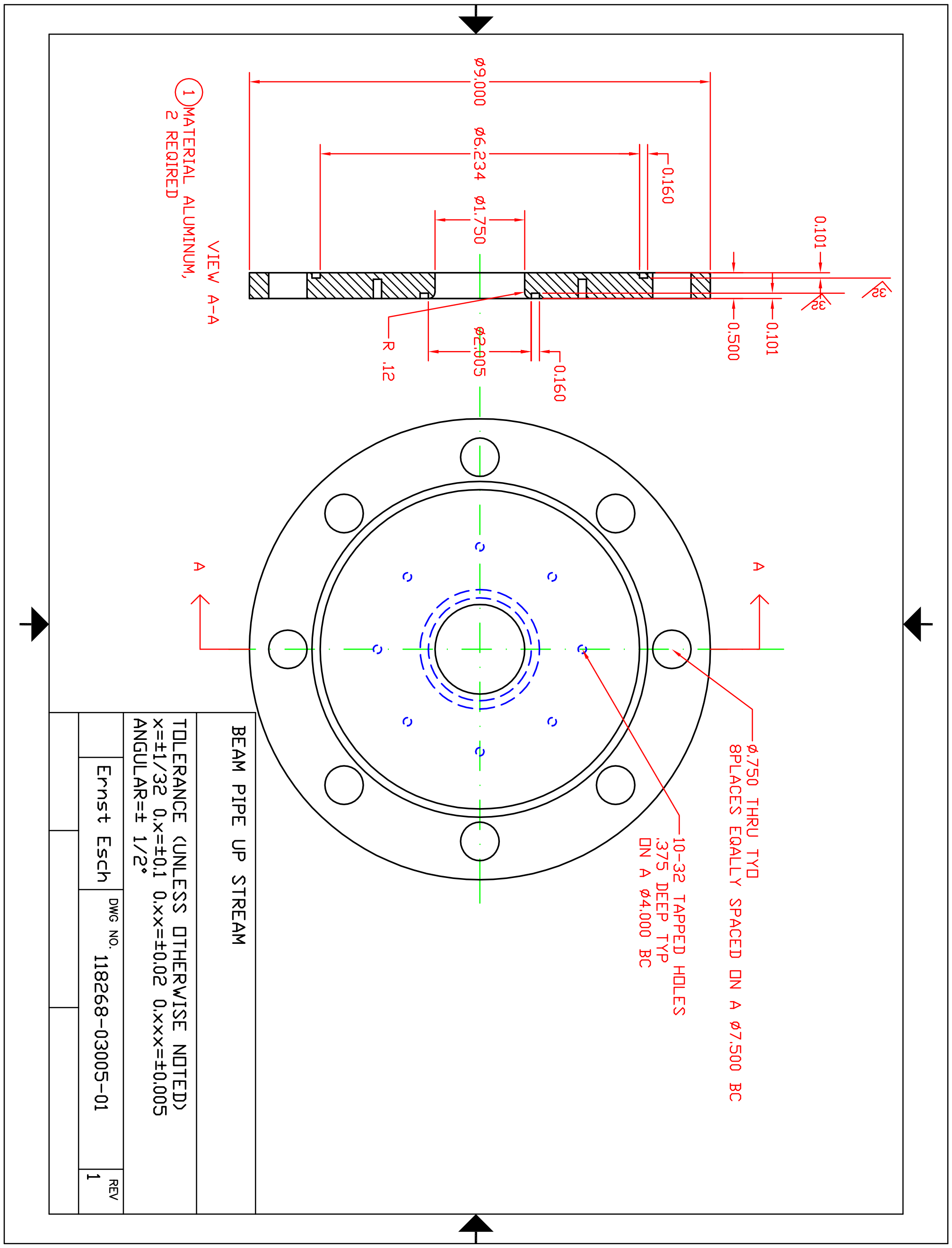

VIEW A-A
1 MATERIAL ALUMINUM,
2 REQIRED
ø9.000
ø6.234
ø1.750
ø2.005
0.160
0.160
0.101
0.101
0.500
R .12
A
A
ø.750 THRU TYP
8PLACES EQALLY SPACED ON A ø7.500 BC
10-32 TAPPED HOLES
.375 DEEP TYP
ON A ø4.000 BC
BEAM PIPE UP STREAM
TOLERANCE (UNLESS OTHERWISE NOTED)
x=±1/32 0.x=±0.1 0.xx=±0.02 0.xxx=±0.005
ANGULAR=± 1/2°
Ernst Esch
DWG NO. 118268-03005-01
REV 1

Figure 14:

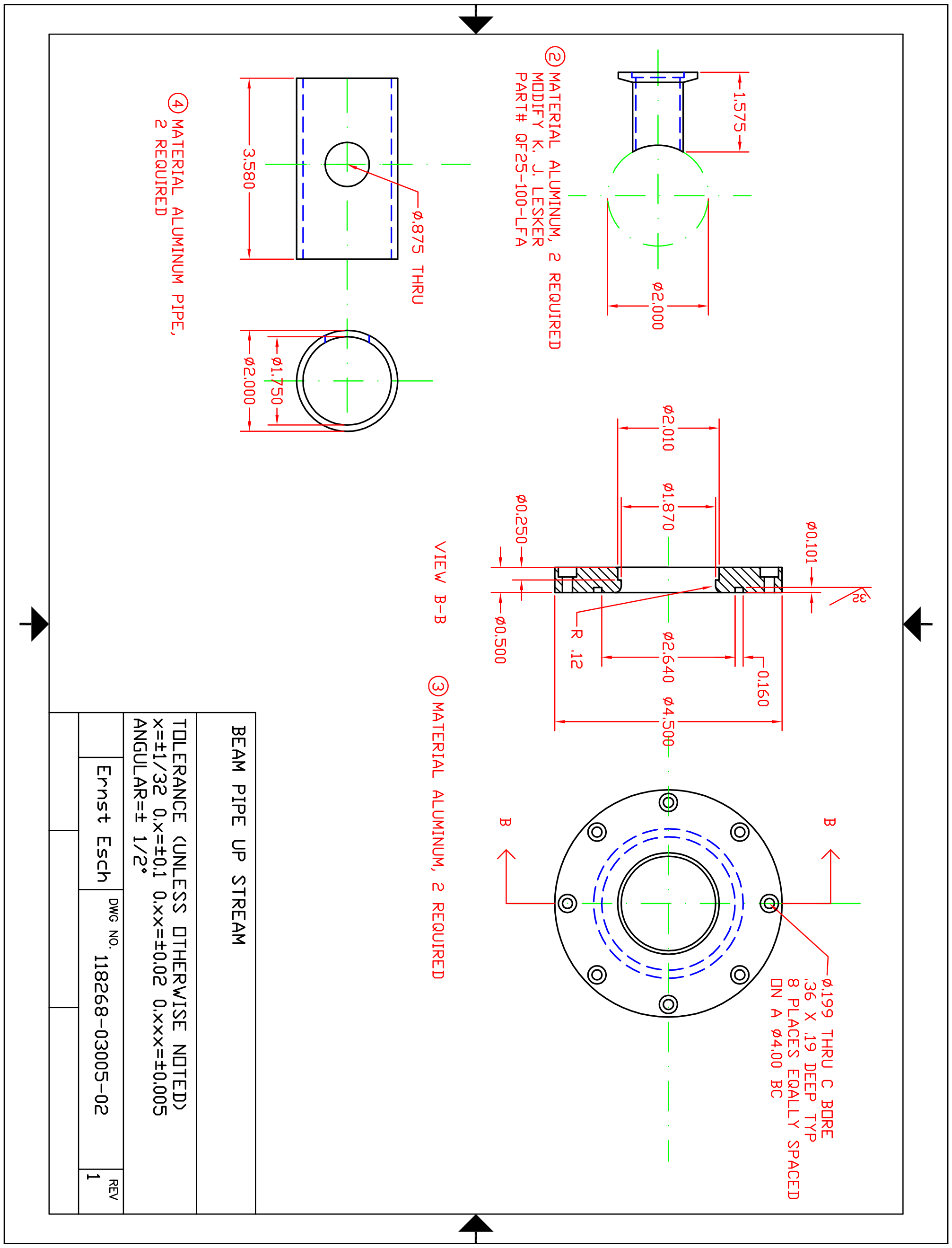

BEAM PIPE UP STREAM
TOLERANCE (UNLESS OTHERWISE NOTED)
x=±1/32 0.x=±0.1 0.xx=±0.02 0.xxx=±0.005
ANGULAR=± 1/2°
Ernst Esch
DWG NO.
118268-03005-02
REV
1
② MATERIAL ALUMINUM, 2 REQUIRED
MODIFY K. J. LESKER
PART# QF25-100-LFA
1.575
Ø2.000
③ MATERIAL ALUMINUM, 2 REQUIRED
VIEW B-B
Ø2.010
Ø1.870
Ø0.250
Ø0.101
Ø0.500
R .12
Ø2.640
Ø4.500
0.160
Ø.199 THRU C BORE
.36 X .19 DEEP TYP
8 PLACES EQUALLY SPACED
ON A Ø4.00 BC
B
B
④ MATERIAL ALUMINUM PIPE,
2 REQUIRED
3.580
Ø.875 THRU
Ø1.750
Ø2.000

Figure 15:

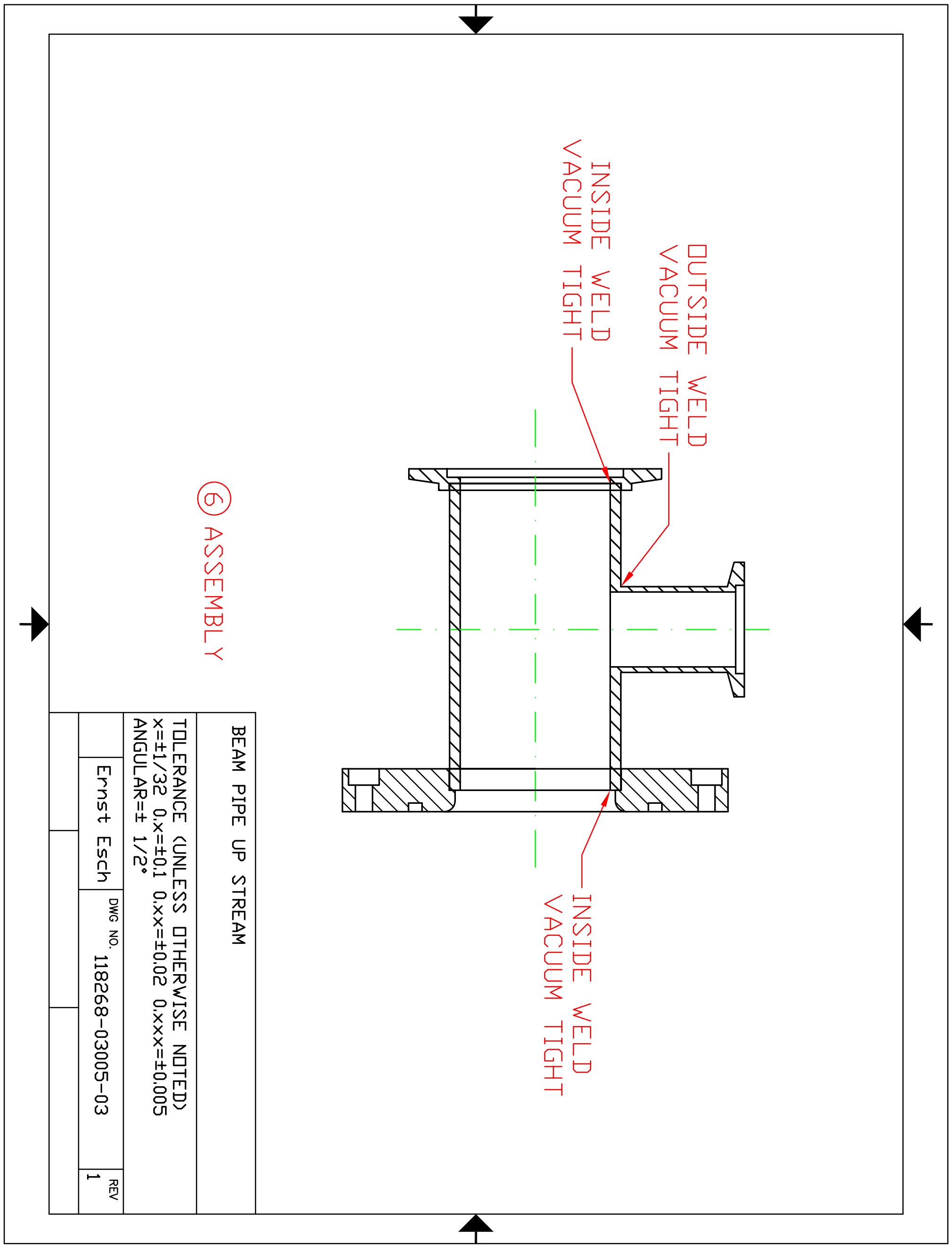

INSIDE WELD
VACUUM TIGHT
OUTSIDE WELD
VACUUM TIGHT
INSIDE WELD
VACUUM TIGHT
6 ASSEMBLY
BEAM PIPE UP STREAM
TOLERANCE (UNLESS OTHERWISE NOTED)
x=±1/32 0.x=±0.1 0.xx=±0.02 0.xxx=±0.005
ANGULAR=± 1/2°
Ernst Esch
DWG NO.
118268-03005-03
REV
1

Figure 16:

pipe. The beam pipe was connected to a roughing pump that could be valved off by valve 1 (see figure 17) on one side and a let-off valve (valve 2) on the other. To see if the RTH's could withstand the forces on the kapton windows during the evacuation and let-off phase the beam pipe was pumped down by opening valve 1. After evacuation valve 1 was closed and valve 2 was opened and the beam pipe was rapidly let off to atmosphere pressure. The kapton foil was observed and the procedure was repeated 4 more times. All tested RTH's sowed no crack or fatigue in the kapton windows.
RTH number 1 was then put into the pipe and valve 1 and two was opened. This created a permanent air flow around the RTH. The experiment was conducted for 60 minutes. Convex warping of the kapton foil in airflow direction was observed. After the 60 minutes the RTH was removed and the kapton was inspected. The kapton stayed glued to the RTH and the observed stretching was in the elastic deformation region.
Therefore it is to be concluded that the kapton windows will not burst or come unglued in an accidental certain vacuum failure.

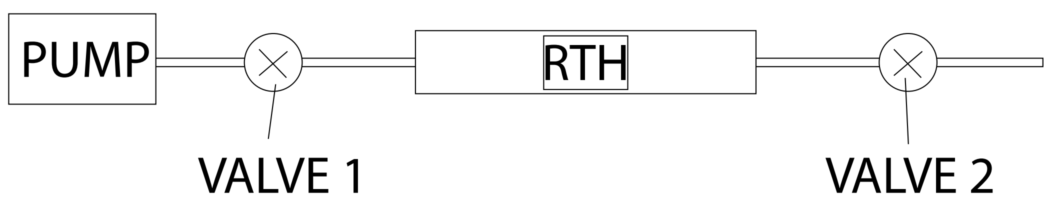


Figure 17: Vacuum system for the RTH window test.

4 Impact Test

To investigate how an RTH holds up under unusual stress condition one RTH underwent an impact study. The RTH was loaded with a 25 μm thick Ti carrier foil that will be used as backing for the electro-plated targets (see Figure **??**). Then the RTH was dropped from a height of 9 m onto a paved floor. The test was repeated once. The firs time the RTH hit on the kapton foil window, but even though the foil was dented, it was not punctured. The aluminum carrier ring had come off of the epoxied connection and the Ti backing was ripped but not torn to pieces. The aluminum carrier ring was bent by the impact (See Figures 19.

The second time the RTH landed on the the corner of the window. The impact permanently deformed the diameter of one end by .005" in diameter out of round. The kapton foil windows were not punctured. Figures 20 and 21 show more details.

Figure 18: Picture of a RTH.

5 Conclusion

The design of the RTH shows in the vacuum tests, that the kapton windows will stand the force of being pumped on at any rate. The tests also revealed that the kapton windows will not break under a condition were the vacuum system fails and vents suddenly to air.

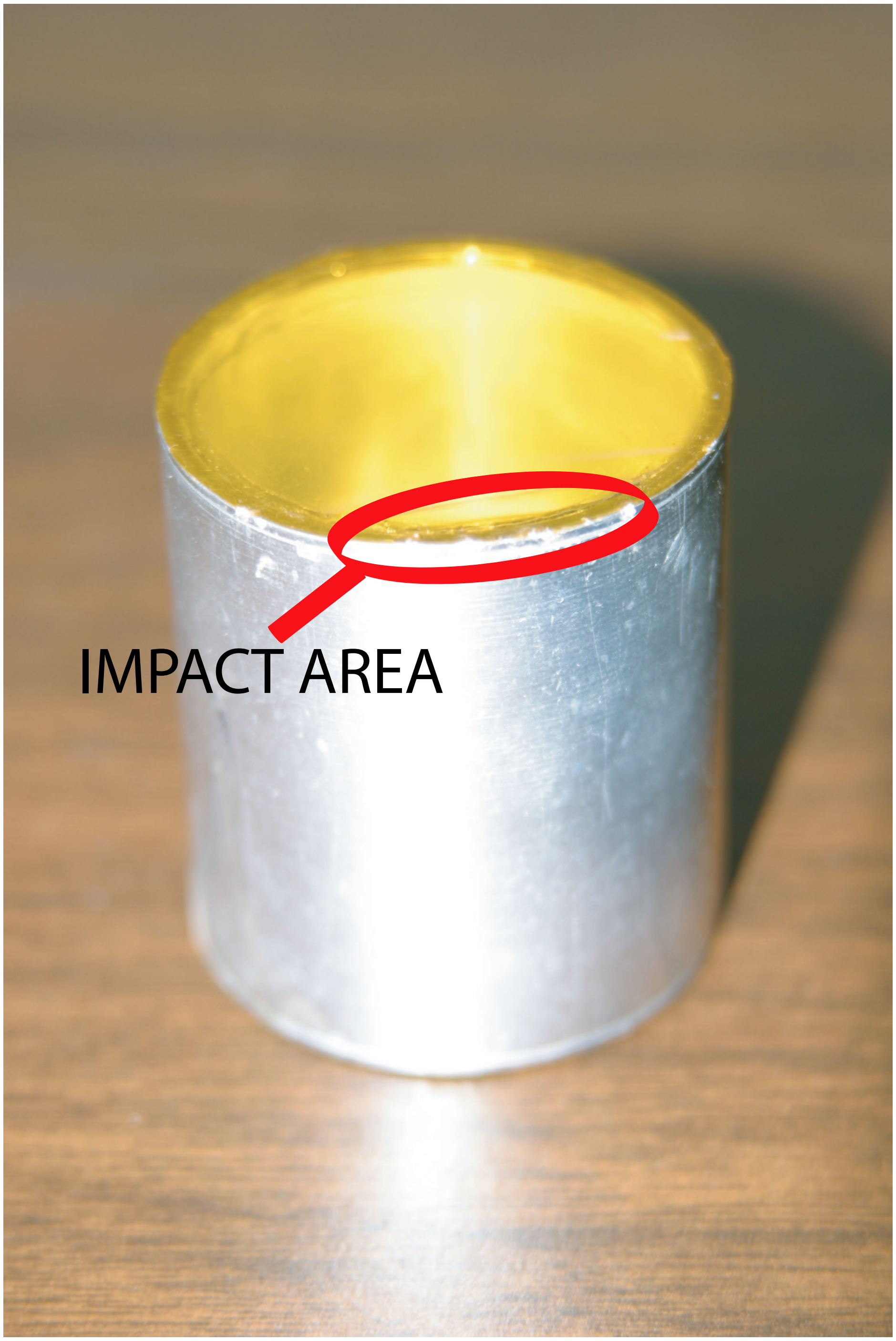


Figure 19: Impact area of the RTH.

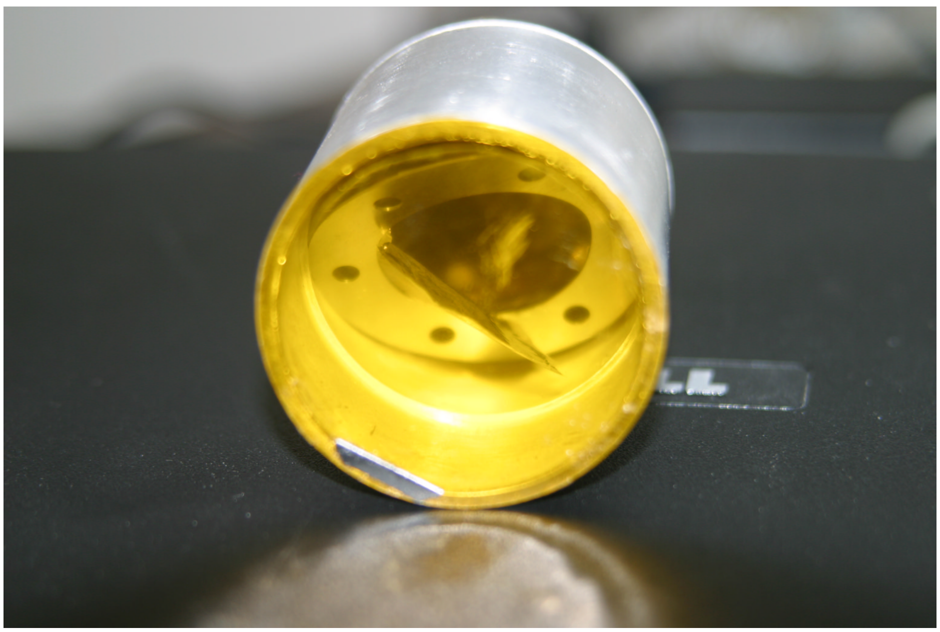


Figure 20: View into the RTH after the drop.

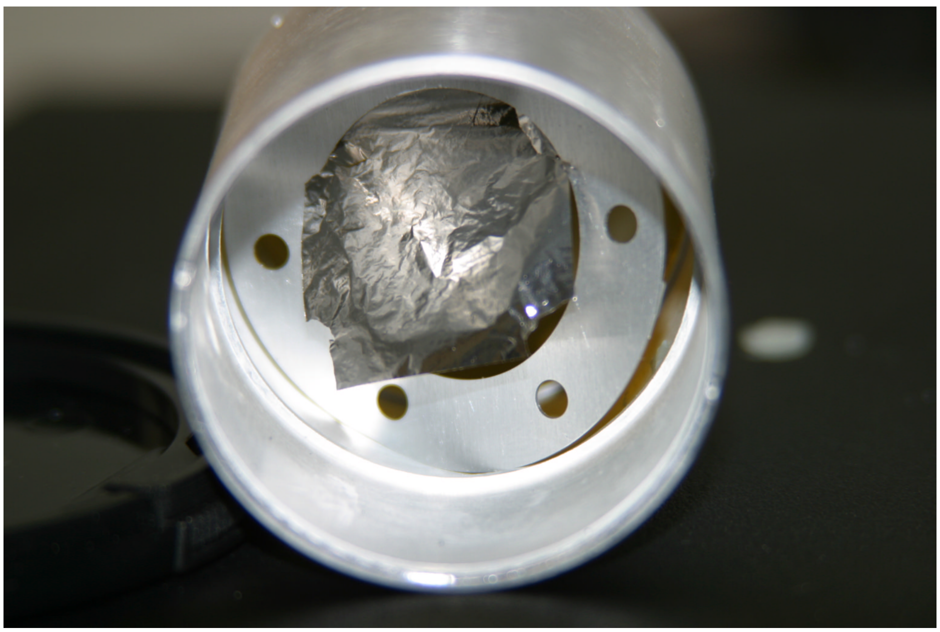


Figure 21: View of the inside of the dropped RTH.